

Modeling of Multifamily Residential Parking Use in King County, Washington

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Multifamily residential buildings often provide too much parking, which can be an impediment to a wide range of community goals. An oversupply of parking can have deleterious effects on economic development, consumers, the community at large, and the environment. Despite a recent surge in research, a lack of consensus still exists on the factors that drive demand for parking in multifamily buildings across a variety of urban and suburban contexts. Although sociodemographic, housing, and built environment variables have all been shown to have an impact on residential parking and vehicle availability, their relative influence is a source of debate. This research identified independent variables to be tested in a regression analysis of 208 multifamily parking use studies conducted in King County, Washington, in 2012. Parking use was correlated to building characteristics as well as to the neighborhood in which the building resided. The final model derived from this regression analysis contained a goodness of fit with an R^2 value of 81.0% and incorporated seven variables: five pertained to the property or development characteristics and two to the built environment, specifically to access. The results of this study were intended for use by practitioners on an interactive website tool, the King County Multi-Family Residential Parking Calculator (www.rightsizeparking.org), which condensed the research findings into a simple, map-based format, accessible to a wide variety of stakeholders.

Today, multifamily residential buildings often provide too much automobile parking, which can be an impediment to achievement of a wide range of community goals. An oversupply of parking can have deleterious effects on economic development, consumers, the community at large, and the environment. The high cost of parking construction and maintenance drives up the cost of housing and reduces the supply of affordable housing. Unless parking costs are separated from the cost of housing (i.e., unbundled) households are forced to pay for parking regardless of their needs. Even when parking costs are unbundled, developers often cannot charge the full cost-recovery price for parking, given concerns about customer sticker shock. In King County, Washington, parking made up 10% to 20% of the cost to construct multifamily buildings, but only 6% was recovered through parking charges (King County Metro Transit parking pricing and

travel demand management for multifamily developments, Seattle, Washington, 2013, unpublished data). Such cross subsidization, or recovery of part of the parking investment through higher rental rates, creates a distorted parking market and reduces the opportunity to use pricing as a tool to manage parking demand. Lower-income households are burdened especially by this distortion, because typically they have lower rates of auto ownership and spend a larger percentage of their income on housing (1). In addition to pricing distortions and reduced affordability, excess parking consumes more land, which contributes to sprawl, lower-density development, and greater distances between buildings. Those outcomes can deter walking, transit use, and efficient transit service operations. Finally, an oversupply of parking can damage natural landscapes through urban sprawl, increase impervious surfaces, and add to greenhouse gas emissions (2). However, the provision of too little parking can impose risks on real estate marketability and can have an impact on nearby on-street parking. These considerations suggest that a right size can be found for parking, which strikes a delicate supply-to-demand balance that ensures real estate marketability, minimizes the impact on nearby on-street parking, and does not present a barrier to the achievement of community goals.

These considerations pose challenges for communities that want to encourage multimodal transportation options and promote smart growth land use planning strategies. In auto-dominated suburban developments with little transit service, parking decisions are more straightforward. Planners or developers could apply findings from parking generation studies conducted in similar communities across the country and set out in the Institute of Transportation Engineers (ITE) *Parking Generation* manual. However, parking supply decisions become more complicated as suburban communities introduce more compact development, mixed uses, and new multimodal transportation options as they welcome a more diverse demographic of multifamily housing users. Current suburban parking generation studies do not meet the objectives in such settings, because they do not account for factors that may influence parking demand.

Academics and practitioners have responded to this gap in research through a growing body of studies, which show how an oversupply of parking can lead to increased auto ownership, vehicle miles traveled, congestion, and housing costs (1, 3). In addition, studies have shown that misaligned parking policies present barriers to smart growth and efficient transit service (4, 5). There is some agreement that parking supply and pricing have a significant impact on parking demand and auto ownership, but these variables have been understudied (2, 6, 7). Despite a recent surge in research, a lack of consensus still exists on the factors that drive demand for parking and account for the variation in auto ownership in multifamily buildings within a variety of urban and suburban contexts. Although sociodemographic,

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housing, and built environment variables have all been shown to have an impact on residential parking and vehicle availability, their relative influence is a source of debate.

The research reported in this paper intended to apply extensive data collection and analysis to provide clarity on the factors that influenced parking demand in multifamily developments. Specifically, the objectives of this research were to identify independent variables to be tested in regression analysis of 208 multifamily parking use studies conducted in King County in 2012. A model of parking use was developed with regression analysis, and the results were intended for use by practitioners on an interactive website tool. It was believed that new data, research, and tools could help developers, financiers, jurisdictions, and neighborhood groups to better estimate the optimum amount of parking for new multifamily developments, especially in complex, growing suburban areas. This research was conducted as a part of King County Metro's Right Size Parking Project, funded by FHWA's Value Pricing Pilot Program.

LITERATURE REVIEW

Several recent studies have begun to highlight the oversupply of parking that exists at multifamily residential properties. To make the case that transit-oriented developments (TODs) are overparked, Cervero et al. looked at 31 multifamily residential housing complexes within $\frac{1}{2}$ of a mile of rail transit in Metropolitan Portland, Oregon, and in the East Bay region of San Francisco, California (2). They found that the average amount of parking built for all projects was 1.57 spaces per unit, above the ITE's rate of 1.2, as well as the average observed demand of 1.15. Although Cervero et al. concluded that TODs in these regions were overparked, they did not fault the ITE rates for the inflated supply of parking and in fact stated that in these cases parking demand aligned fairly well with ITE guidelines (2). Further research into the mismatch between parking supply and demand at TODs in the Bay Area found that approximately 26% of the parking spots were unused at 12 residential projects around Santa Clara Valley Transportation Authority light rail and California Department of Transportation train stations. On average, only 1.3 spaces per unit were occupied during the period of peak demand, while 1.7 spaces were supplied (8).

Similarly, research in Southern California's Inland Empire found that the supply of parking exceeded demand by about 16% at suburban multifamily housing projects. However, the observed demand exceeded ITE rates by 38% (5). A comparison of multifamily buildings at an urban and suburban center in King County found an oversupply of parking at both locations, with greater excess at the suburban location (i.e., 0.58 spaces per unit) than the urban one (i.e., 0.22 spaces per unit). In addition, demand was less than the ITE rates at both types of centers, but the difference was much more dramatic in the urban center, where observed demand was about half of the ITE rate (9). Parking requirements also affect the type of housing that developers build. After a partial deregulation of residential parking in Los Angeles, California, Manville and Shoup found that, when parking requirements were removed, developers supplied more housing and less parking, as well as different kinds of housing (e.g., in older buildings, disinvested areas) and housing marketed to nondrivers (10).

In their study of parking at TOD housing complexes in the Bay Area and in Portland, Cervero et al. found that sociodemographic variables that related to the surrounding neighborhoods had no effect on parking demand (although they did not look at project-

specific household characteristics). In addition, through the use of multiple regression analyses, they ascertained no significant correlation between parking demand and project density or rent levels. The most significant predictors of parking demand they found were parking supply and project land area (acreage), as well as walking distance to and peak headways of nearby rail stations (2). In San Diego, California, parking at multifamily rental housing projects was surveyed and, in contrast to Cervero et al.'s findings, proximity to transit was shown to have little effect on the demand for parking at affordable units, but a stronger relationship was observed with parking demand at market rate properties. Average demand for parking spaces at affordable units was lower than at either type of market rate property, which indicated a contributing influence of sociodemographic factors (11). Further research in San Diego found that vehicle availability at affordable housing units (0.68) was far below the city average for rental housing (1.44), and peak occupancy at the affordable units was even lower (0.53 spaces per unit). Among the affordable units studied, transit availability and walkability were correlated with vehicle availability (12).

With respect to vehicle ownership in New York City, sociodemographic variables (e.g., income, family type, number of children) were all found to be significant. Overall, close proximity to transit correlated with lower auto ownership by 0.25 vehicles, with more pronounced impacts in Brooklyn and Queens, New York (13). Willson's assessment of parking demand in California's Inland Empire used American Community Survey and household survey data to test for factors that accounted for the differences in vehicle availability. Only household income and the year the property was built were statistically significant; household size, the number of bedrooms, and the presence of a Metrolink rail station were not (5). Transit can help to minimize parking demand through the provision of an appealing and feasible alternative to driving (2, 11, 12). In a study of trip generation at mixed-use developments, Ewing et al. found that transit use was highly elastic with respect to vehicle availability (14).

A limited number of endeavors have been undertaken to develop new models to estimate parking demand that are sensitive to the range of sociodemographic, housing, and built environment variables shown to be influential. Nonetheless, a longstanding history of research exists that has attempted to relate some or all of these variables to auto ownership. An examination of the effect of density on auto ownership used the 1990 Nationwide Personal Transportation Survey. Statistically, household income and size and number of workers were the most significant determinates of auto ownership. Three neighborhood characteristics (i.e., density, central city location, transit availability) also were tested and found to be significant. However, Schimek argued that, after other demographic and geographic factors were controlled for, density had only a modest impact on auto ownership (15).

Holtzclaw et al. developed models to predict auto ownership and vehicle miles traveled per household in San Francisco, Chicago, Illinois, and Los Angeles. Census data from 1990 on vehicles available and 1990 to 1995 odometer reading data were fit to socioeconomic and built environment variables thought to explain the observed variation. With regard to autos per household, the variables with the most explanatory power were net residential density (households per residential acre), per capita income, household size, and transit access. The presence of local shopping was found to be strongly correlated with density and transit and its inclusion did not affect the significance of the model once these variables were accounted for. Combination of the data sets from the three regions produced results that were similar, but not as strong, which suggested that other important variables might not have been identified (16).

A weakness of many studies that looked at parking demand or auto ownership was the omission of data on parking availability, cost, and pricing. These three factors impact demand yet have been understudied with respect to multifamily residential parking (2, 6, 7). Guo found that free and available on-street parking increased private car ownership by nearly 9% in the New York region, even when off-street parking existed. However, he noted the lack of data on on-street and off-street parking, and the limitations of alternative sources as estimates, which in this case were Google and Bing maps (7).

METHODS

Although sociodemographic, housing, and built environment variables have all been shown to have an impact on parking and vehicle availability, their relative influence is a source of debate. The present research reported here attempted to address and provide clarity on these issues in addition to provision of practical tools to use in development and policy discussions. Information provided in this section summarizes the process used to model the influence of these variables on parking use through regression analysis. Specifically, this section details the process to

- Select multifamily development sites for field data collection;
- Identify independent variables, from a theoretical framework and a practical development and planning standpoint, to be tested in regression analysis of parking use data collected;
- Conduct statistical analysis to test independent variables' significance to predict parking use; and
- Develop a model of parking use with regression analysis, with the criteria that all variables are significant and multicollinearity is minimized.

Site Selection Process

Multifamily sites that numbered 223 were assembled with the use of convenience and quota sampling techniques to represent various types of multifamily development around King County. The sites were assembled to provide a well-distributed sample and contribute the dependent variable and many of the site-specific independent variables. Eligible sites included multifamily residential properties with a size equal to or greater than 10 units, either leased as apartments or sold as condominiums. If the property contained mixed uses within the development, only the residential portion of the parking supply was studied. The geographic location of eligible properties was defined to ensure that the sample was focused in areas in which future multifamily residential development could be developed. Numerous developers, property owners, and property management companies were asked to participate in the data collection effort, and then quotas for transit connectivity, employment access, average medium gross rent, and average median household income were established to reflect the full distributions and ensure a representative sample.

Dependent Variable

The dependent variable used in the model to estimate parking use was "observed vehicles per occupied residential unit," collected from

the field data. Parking use in multifamily buildings was observed on Tuesdays through Thursdays, between midnight and 5 a.m., for all residential parking, including visitor parking, identified by the property manager at each multifamily development. Parking was mostly provided in off-street garages or lots located on the multifamily parcel, but sometimes in dedicated on-street stalls or satellite garages. Sites selected for the study were screened for building age and available parking supply to control for potential undersupplied parking where spillover could occur. The end result was identification of sites at which the predominant parking could be measured through parking counts, with the exclusion of sites at which undefined off-site, on-street parking might have resulted in underrepresentation of parking use.

Independent Variables

During the regression analysis and model development process, more than 100 distinct, potential independent variables were grouped into the following five categories: parking supply and price, property and development characteristics, neighborhood household characteristics, accessibility, and built form and development patterns. The categories were analyzed, which enabled consideration of the greatest number of possible variables to capture these factors. Because one variable could be represented in many formats with different metrics, an extensive list of potential explanatory variables was analyzed. For example, although it was expected that transit access would correlate with parking use rates, the best measure of transit access to best explain use rates was unknown.

Regression Analysis

With the initial presumption in regression analysis that the ordinary least squares would provide the optimal approach (and other methods were pursued only if ordinary least squares proved inadequate), a simple linear regression model was used. However, because relationships between the dependent and independent variables were not all assumed to be linear, all variables were tested with various transformations (e.g., natural log, inverse, square root). Variables were tested for their correlation with the dependent variable as well as for the form that worked best and made the most sense.

To construct the regression analysis, many approaches were tested to find the best method to include, remove, and find the best set of variables. In the end, the goal was to find the set of variables that made the most sense in terms of a theoretical framework and from a practical development and planning standpoint, while it was kept in mind that the resulting formula ultimately had to be applied and used in an online tool. Maintenance of the criteria were considered throughout that (a) all variables be significant (i.e., the probability that the coefficient was nonzero, or p less than .05) and (b) all multicollinearity be low (as assessed through variance inflation factors or values less than 5). Because each factor or characteristic was represented with many independent variables (as well as multiple transformations of each), multicollinearity, or a high level of correlation between independent variables, was an important consideration.

The most effective modeling approach identified, which became the basis for the parking use model, started with a set of variables that appeared in the highly scoring results of multiple approaches. A stepwise method was used, with an entry criterion of .05 and a removal criterion of .10 for the probability of f . Variables were then

considered on the basis of their logical candidacy within a planning or development context. For example, a variable was removed if it represented the count of three-bedroom units in the final set of variables but no other count or average number of bedrooms was included. Variables that pertained to average bedroom counts were added and tested in a stepwise method. If two variables had high collinearity (e.g., block size, transit connectivity index), one was removed; various variables were tested to replace the other.

Throughout this process, outlying cases were tested to ensure that no one outlying property influenced the fit too significantly. Cases (i.e., sample properties) with high-leverage values (approximately >0.5) or outlying residuals (identified through separated tails in a residual histogram) were removed from the sample. In the end, 15 cases were removed on the basis of these criteria, which yielded a final sample of 208 properties.

Supply of Parking

Supply often is cited as one of the most important variables in the determination of demand, and many past studies found high correlations between the two factors. A high correlation was found in the data in this research as well, and the added explanatory power that parking supply contributed to predict parking use indicated that it should be included in the model. However, estimation of parking use to inform supply decisions should not be a function of supply. In other words, parking was excluded from the model because its inclusion would address a different research goal. If supply was included in the regression model, its coefficient would indicate the effect of parking supply on use, contingent on the other observable characteristics included in the model. Such a result differed from the research objective in this study, which was to estimate the full quantity of parking that would be demanded at a given property to help inform a decision on the level of supply. It was not desirable for the model to capture situations in which parking use was low, purely because little parking was supplied, rather than because little was demanded. Therefore, parking supply was excluded as an independent variable from the model.

RESULTS

The final model derived from this regression analysis incorporated seven variables: five that pertained to the property or development characteristics and two that pertained to the built environment or specifically to access. The goodness of fit was explained with an R^2 value of 81.0%, an adjusted R^2 value of 80.3%, and a standard error of 0.16 parking stalls per occupied housing unit.

$$P_u = b + \sum_{i=1}^7 C_i X_i$$

where

P_u = modeled value of parking use,

b = constant term,

C_i = coefficient for i th variable (derived from regression equation in Table 1), and

X_i = value of i th variable that represented a location or building characteristic.

Summary of Findings

Parking use was shown here to be correlated to the building characteristics but also to the neighborhood in which the building resided. In other words, parking use could not be determined from the characteristics of the building alone, nor from the setting alone. To understand and accurately assess parking needs, both elements must be considered in conjunction.

Table 1 shows the seven variables, the transformations used, the coefficient values, the estimate error on the value, the individual R^2 values, and the stepwise R^2 values. Individual R^2 values represented the correlations between the given variable and the dependent variable. The stepwise R^2 value represented the improved R^2 value, because each variable was added to the final model. Figure 1 shows the results of the final fit, and shows the observed or measured data versus the predicted model results.

Independent Variables

Gravity Measure of Transit Frequency

Gravity measures take into account the quantity and proximity of the factor that is being measured through calculation of the quantity, divided by the distance squared from a given parcel's centroid. Therefore, the gravity measure of transit frequency accounts for all transit stops and stations, scaled by the frequency of service, and then sums the value to each parcel on the basis of the distance from the given parcel. This measure can best be understood as a measure of concentration.

Many measures of transit access correlated strongly with parking use. The research data indicated that the natural log transformation of concentration of transit frequency and observed vehicles per occupied unit showed a tight fit, and the R^2 of 55.5% confirmed this indication. Transit access measures also correlated strongly with many other variables that pertained to the built environment (e.g., average block size). Therefore, the inclusion of a transit access measure in the model precluded the use of many other built environment or location characteristics, because multicollinearity would have been a problem. However, this finding was viewed as positive with respect to the indication that transit was located and concentrated in areas in which other built environment variables were high, and it could account for many factors.

Percentage of Units Designated Affordable

This variable included all units identified as affordable by any designation as a percentage of all units (regardless of occupancy). The data indicated that as the percentage of affordable units went up, parking use went down. In this case, the square root of the variable was the transformation that had the strongest correlation and was used in the final model. This trend was one frequently noted and agreed on in the literature: affordable developments or those geared toward lower-income households tended to demand less parking per unit.

Average Occupied Bedroom Count

Average occupied bedroom count is the average number of bedrooms in all occupied units. To calculate this average, studio units were assumed to have a bedroom count of one. The data indicated that the

TABLE 1 Summary of Regression Results

Variable	Range	Average	Median	Transformation	Transform Description	Coefficient	Estimated Error	Individual R^2	Stepwise R^2
Constant	na	na	na	na	na	1.98	.25	na	na
Gravity measure of transit frequency	44,475–16,093,173	1,291,217	583,114	Natural log	Log used because of long high end tail	–0.067	.017	55.5%	55.5%
Percentage of units designated affordable	0%–100%	23.74%	0%	Square root	Square root used to flatten out distribution that was peaked low	–0.0230	.0037	27.6%	67.1%
Average occupied bedroom count	1.0–3.0	1.52	1.49	Inverse	Transform to units per bedroom	–0.360	.088	34.3%	73.7%
Gravity measure of intensity (population and jobs)	55,243–373,613	181,821	134,191	Inverse	Inverse used to reduce effect of high tail	35,353	6,016	53.3%	76.2%
Units per residential square feet	0.00022–0.01342	0.0014	0.0012	Inverse	Transform to size of unit in square feet	0.000139	.000031	17.1%	78.7%
Average rent	\$315–\$5,800	1,269	1,239	Inverse	Flatten out distribution	–154	39	6.7%	80.0%
Parking price as fraction of average rent	0–0.19	0.04	0.03	Square root	Square root used to flatten out distribution that was peaked low, due to numerous zero parking prices	–0.33	.10	18.1%	81.0%
Observed parked cars per occupied unit (dependent variable)	0.07–1.9	0.963	0.959	na	na	na	na	na	na

NOTE: na = not applicable.

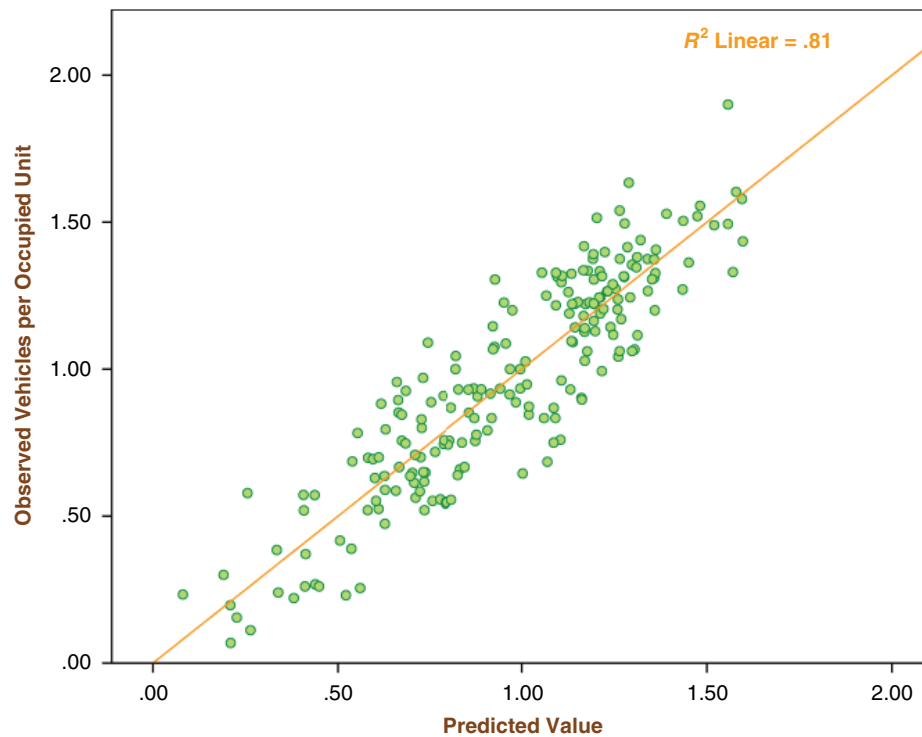


FIGURE 1 Observed vehicles per occupied unit versus modeled value.

average count of bedrooms had a positive correlation with parking use: as the average bedroom count went up, so did parking use. The inverse transformation had the strongest correlation and was used in the model.

Gravity Measure of Intensity: Population and Jobs

As described, gravity measures take into account the quantity and proximity of the factor that is being measured through calculation of the quantity, divided by the distance squared from a given parcel's centroid. In the case of intensity, the factor that was being measured was the sum of population and jobs. Therefore, through an understanding of this factor as a concentration, a high value can be the result of highly concentrated residential populations, highly concentrated jobs, or some combination of the two.

Previous research often found a strong correlation of residential density and job access with auto ownership. The strong correlation of the gravity measure of intensity and observed vehicles per occupied unit observed in the data in this present study supported these findings. Measures of population concentrations, population and household density measures, and various measures of job access all correlated strongly with use: as people, jobs, or both, concentrate, parking use goes down. The inverse of the gravity measure of intensity was the variable that worked best in the model.

Units per Residential Square Feet

Obtained from the property managers, the number of units per residential square feet was calculated as total residential units, divided by the residential square feet of the development. This variable essentially

captured the average size of units (i.e., the greater the units per square feet, the smaller the units). The data in this study indicated that, as units per residential square feet went up, or average unit size went down, parking use went down. Again, the inverse transformation showed the strongest correlation and was used.

Average Rent

Obtained from the property managers, average rent represented the average monthly costs of all residential units in a building. The study data indicated that, as average rent went up, so did the observed parking use. The inverse transformation was used because of its stronger correlation.

Average rent (in dollars) was not one of the variables with a very strong correlation by itself (R^2 of 6.7%). However, when added to the set of variables that constituted the model, average rent was significant and added more explanatory power than many variables with higher individual correlations.

Parking Price as Fraction of Average Rent

Parking price as a fraction of average rent is calculated as the monthly price of parking per stall, divided by the average monthly rent. In properties with unpaid parking, this value is zero. This value approaches 1 as the cost of parking nears the cost of rent. According to basic economic theory and much literature, price should affect demand. However, parking price, as a dollar figure in and of itself, showed a very low correlation with parking use. A monthly parking price of \$100, for example, was felt very differently in residential developments that were inexpensive than in ones that were

expensive. To account for this fact, parking price as a fraction of rent was used and correlated much more strongly with parking use. The data in this study indicated a negative trend, which showed that, as the parking price neared the cost of rent, parking use went down. The square root transformation was used, because it correlated best with the dependent variable.

LIMITATIONS

The final model that resulted from this regression analysis can help support and guide decisions about parking supply and management. It cannot provide definitive answers about specific future policies or developments but can serve as a resource to inform discussions as users weigh the factors that affect parking use and consider how much parking to provide.

Model Estimates and Data Collection

Statistically, the final model was strong. For planning purposes, however, it is important to note that it is merely a model and that error always occurs in estimates. Limitations on data collection also affected the model's accuracy. Observed parking mostly included supply that was on-site and off-street, unless additional parking provided for residents was noted by property managers. However, the sites selected for the study were screened on the basis of building age and available parking supply, to control for potential undersupplied parking that could result in spillover. The result was sites studied whose predominant parking could be measured through parking counts, rather than those where undefined off-site parking would have resulted in an underrepresentation of parking use. As a result of a lack of on-street parking data and limitations on scope, this research was not able to fully account for on-street parking supply, occupancy, and pricing in the modeling of off-street multifamily parking. With the use of neighborhood on-street parking counts and residents surveys, future research opportunities exist to establish a more comprehensive understanding of multifamily parking demand.

In addition, data used in the model were collected and compiled that represented one point in time. As factors of the built environment change (e.g., transit service is expanded), and parking use changes, it will be necessary to update independent and dependent variables and reassess their relationships.

Model Coverage

To ensure confidence in the model estimates, limits were established for the coverage area. The sample used for data collection covered a wide range of built environment characteristics and land uses, but it did not cover the full spectrum found throughout the county. Therefore, the coverage for which model estimates were calculated was limited to the range of built environment characteristics found in the data collection sample. In other words, areas of the county that had lower transit service, population, or job concentrations than those found in the sample were removed from the coverage area.

APPLICATION

A principal goal of the Right Size Parking project was to provide stakeholder access to this research. The King County Multi-Family Residential Parking Calculator (www.rightsize-parking.org), shown as a screenshot in Figure 2, condenses complex research findings into a simple, map-based format, accessible to a wide variety of stakeholders. With use of the model to estimate parking use, resulting outputs for most developable parcels in King County are illustrated on this interactive, mapping website. Users can select a parcel, input details specific to a proposed development, adjust factors of the built environment, and see the new estimated parking use. The ability to alter these characteristics and compare the impacts of alternative scenarios enables stakeholders to weigh factors that will affect parking use at multifamily housing sites as they make economic, regulatory, and community decisions about development.

To highlight the impact of parking price and presence of affordable units on parking use, the website automatically calculates and displays the different parking use estimates for a given parcel and building with (a) parking pricing bundled with rent or unbundled from rent and (b) 100% affordable units or no affordable units.

With the use of best available research findings and accepted rule of thumb assumptions in the industry, additional impacts were estimated to highlight the additional costs of parking for display on the right-size parking calculator website. Impacts calculated included total capital costs of parking, monthly costs per residential unit, greenhouse gas emissions from construction and maintenance, annual vehicle miles traveled of building residents, and greenhouse gas emissions from vehicle use by residents.



FIGURE 2 King County Multi-Family Residential Parking Calculator. (www.rightsizeparking.org).

CONCLUSIONS

This research developed a rich data set, powerful model, and valuable website to communicate research findings to a wide variety of stakeholders. These products can be used to help shape development in ways that optimize parking supply, including the following:

- Jurisdictions can adjust zoning codes to reflect local characteristics of parking demand.
- Developers and financiers can minimize project cost and risk through the determination of the right amount of parking needed in new developments.
- Neighborhood residents can inform their participation in neighborhood planning and development.

Through the guidance of locally credible and context-sensitive data on parking use, such as the kind provided in this research, communities have the opportunity to support economic development, reduce housing costs, encourage transit use, and reduce vehicle miles traveled. Through the reduction in barriers to building mixed-use multifamily residential developments in urban centers near transit infrastructure, economic development goals can be achieved. Housing and transportation costs can be reduced, which will allow a larger demographic to participate in the urban, infill housing market. Finally, a reduction in the parking subsidy and the support of smart growth can increase transportation choices and reduce vehicle miles traveled.

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